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XVIII. *A Description of a new System of Wires in the Focus of a Telescope, for observing the comparative Right Ascensions and Declinations of celestial Objects; together with a Method of investigating the same when observed by the Rhombus, though it happen not to be truly in an equatorial Position. By the Rev. Francis Wollaston, LL.B. F.R.S.*

Read April 7, 1785.

IN consequence of a paper communicated the last year to this Society, and honoured with a place in our Transactions, it may be expected of me, that I should now deliver in an account of what farther observations I have made on that constellation of which I then gave a rough map. This I readily would do, if they were in any degree worthy of the Society's notice. But as yet they are far from perfect: how much better they may succeed hereafter, time must shew.

Yet has this year perhaps not quite been lost; the difficulties which disappointed my hopes, having led to what appears to me an improvement in the instrument with which to pursue such observations.

My design, as was hinted in that Paper, was to ascertain, as well as I was able, the right ascensions and declinations of the stars I had laid down; by observing their *meridian passages* and *meridian altitudes*, where that could be done with such small instruments as mine; as also by their *comparative passages* through the field of an equatorial telescope furnished with a

system of wires invented by Dr. BRADLEY, and called by the French *Reticule Rhomboïde*, whence it has commonly obtained in English the name of the Rhomboid.

In the former I was disappointed by the weather; which from the time I went into the country, in the middle of May, till the end of June, when that constellation came to the meridian in the day-light, afforded me very few evenings fit for observation.

In the latter I failed, through the imperfection of my instrument, or my own want of skill in the use of it; for though a single set of observations in any one evening would appear very good, yet when reduced by calculation, and confronted with other repeated trials, they never gave me the satisfaction I wished.

The rhombus (for a rhombus, and not a rhomboid, it ought most properly to be called) is very good in theory; but very difficult to get executed with precision, and liable to some inaccuracy in the observation. The truth of it depends upon the longer diagonal being exactly twice the length of the shorter one; which requires an awkward angle ($53^{\circ} 7' 48''$) at the vertex, not easily to be hit by the workmen, and therefore seldom sufficiently true. Beside this, as the sides of the rhombus, on which depends the calculation for differences of declination, are but $26^{\circ} 33' 54''$ declining from the perpendicular or horary wire, a very small error in observing the passage of a star makes a very material difference in the result.

This determined me upon making trial of a square placed angularly (an addition to M. CASSINI's wires at 45° , as may be seen in tab. XII. fig. 1.) which seems to answer better. I must confess I have not yet had opportunity for trying it so completely as I could wish: but I was unwilling to let this

year slip by, without making it known; since, I think, from what I have done with it, I may be confident of its utility*.

The *properties* and *advantages* of such a system of wires scarcely need to be pointed out to astronomers. The whole extent of the field is employed as it is in the rhombus (the want of which was said to be Dr. BRADLEY's objection to M. CASSINI's wires); but being formed of right angles or half-right angles, to which workmen are most accustomed, they will always be apt to execute their part better; and the obliques, from the differences being just double to what they are in the rhombus, give the comparative declinations with twice the certainty. To this the number of corresponding observations in the passage of every star add considerably; since you may calculate its distance from the center C, from the angle D or E, or from one of the intermediate angles K, as you shall see occasion. The same indeed you may do in the rhombus from D or from E; or, if the rhombus be formed of wires, from the angle at L, fig. 2.; but only with half the precision. The result of a single passage of any one star (excepting towards the extremities of the field) gives the extent of the field equally in each, provided the declination of the star be known, by deducing its distance from those several angles; and such deductions serve as a still farther check upon every observation; be-

* What is here offered is by no means to be understood as recommending any system of wires in preference to actual measurement with a micrometer, but to render the use of them as convenient as may be to such gentlemen as are not provided with better instruments. The equatorial micrometer with a large field (such as I have seen at Mr. AUBERT's, or Mr. SMEATON's construction) I take to be the best instrument for taking differences of right ascension and declination out of the meridian; and far superior to any system of fixed wires, or indeed to any equatorial sector whatever.

cause, if any part of it be thought doubtful, its tallying or not tallying with the known extent of the field will shew whether there be any error, or where it lies. And, in each of them, the parallel wires will tell you whether the placing of your instrument be true or faulty; because, if truly made and truly set, the same star must take the same time in passing from one wire to its corresponding parallel; which will differ considerably, and in every star the same way, if the position be faulty.

Some of these latter remarks might have been spared, but that they may serve as hints to such gentlemen as may be inclined to lend their assistance to what was proposed the last year, and who may not have considered the many helps to be derived from a cross examination of the observations they make. For their use also it may be proper to add, what indeed is nothing new, that if the position of the instrument be found erroneous, the formula given by M. DE LA LANDE in his *Astronomy* will serve to rectify the observation. Calling the larger interval between the passage of any oblique and the horary wire m , and the smaller one n , $\frac{m^2 n + n^2 m}{m^2 + n^2}$ will give the difference of declination (in time, to be converted into degrees; and multiplied by the cosine of declination) from the angle where that oblique meets the horary; and $\frac{m^2 n - n^2 m}{m^2 + n^2}$ the difference in right ascension from the same angle. It must surely be almost needless to mention, that where the position is true, *half* the interval of time between a star's passing any two corresponding obliques, converted into degrees, and multiplied by the cosine of declination, will give the difference in declination of that star from the angle where those obliques meet, as the *whole* interval does in the rhombus.

But

But it may, perhaps, be of service to astronomy, or at least not unacceptable to those gentlemen who use the Rhombus, that I should subjoin another formula (contrived for me the last summer by my Son, now Mathematical Lecturer at Sidney College, Cambridge) for investigating the comparative right ascensions and declinations of stars observed by it, when the instrument is not placed truly in the plane of the equator. I was led into wishing for some such formula, in consequence of an ingenious Paper, kindly communicated to me by Sir H. C. ENGLEFIELD, Bart. F. R. S. giving an account of his method of doing it by a scale and figure; which, though very easy when one is provided with such a scale, appeared to me to be of less general use than by calculation; and I do not know that any thing of the kind is to be met with in any publication.

Let the angle DLL, fig. 2. (which, by construction, is $63^{\circ} 26' 6''$) be called

The diagonal LL (whose extent, that is, what portion of a great circle it comprehends, must be known to the observer) be called

The larger interval observed between the passage of a star by an oblique and the horary wire (as bc)

The smaller ditto of the same star (as cd) n

The larger ditto of another star (as $\beta\gamma$) μ

The smaller ditto (as $\gamma\delta$) ν

Then $\frac{2 \cdot \overline{m-n}}{m+n}$ = tangent of the angle which LL makes

with a parallel of declination: call this q

The angle q being thus found, then

$\frac{2 \cdot \overline{n \sin \nu} \times \sin. \overline{a+q}}{R \times \sin. a} \times \cos. q.$ = difference in declination between the

two points on the vertical wire where
those

those stars pass it. N. B. This being in *time* must be converted into *degrees*, and multiplied by cosine of declination as usual, to give the true difference in declination between the stars.

And the same expression, *viz.*

$\frac{2 \cdot \overline{n \sin. a + q}}{R \times \sin. a} \times \sin. q =$ the difference in *R* between those two points; to be applied as a correction to the observed times.

The same may be done by the larger intervals *m* and μ , only by substituting $\overline{a - q}$ in the place of $\overline{a + q}$, thus:

$\frac{2 \cdot \overline{m \sin. \mu \times \sin. a - q}}{R \times \sin. a} \times \cos. q =$ difference in declination as above;
or $\times \sin. q =$ ascensional difference.

If the stars differ too much in declination to come within the expression above (as N^o 2. and 3.) then the differences of the angles D and E in declination and right ascension may be found thus:

$\frac{2 \cdot b \times \cos. q}{R} =$ difference in declination between D and E;

$\frac{2 \cdot b \times \sin. q}{R} =$ their ascensional difference;

and the difference of each star from its respectively nearest angle of the rhombus, may be deduced by the former expression, leaving out the consideration of the other star, thus:

$\frac{2 \cdot n \times \sin. \overline{a + q}}{R \times \sin. a} \times \cos. q =$ difference of the star in declination from its nearest angle.

and $\times \sin. q =$ its difference in right ascension.

The application of these formulæ is very easy: for having found *q*, if you set down its cosine in one column for declina-

tion, and its sine in another column for right ascension, and under each the constant $\sin. a + q$, and the arithmetical compl. of $\sin. a$; these being added together will make two sums, for the comparative observations of every star which may pass your field; and, unless your field be very large, and the declination of the stars very great, if to the column for declination you add the cosine of declination of the center of your field, it will adapt itself to all the products.

FRANCIS WOLLASTON.

Charter-house-Square,

March 15, 1785.

P O S T S C R I P T.

SINCE the delivery of this Paper, it has occurred to me, that it may sometimes be convenient to know the angle of deviation from the true equatorial position in the new system of wires. This is to be deduced nearly in the same manner as in the rhombus; for $\frac{m-n}{m+n} = \text{tang. } q$. By this angle any observed differences in right ascension may be corrected: for the difference in declination between any two stars (or their difference from the angle) multiplied by $\sin. q$, will give the correction required.

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Fig. 1.

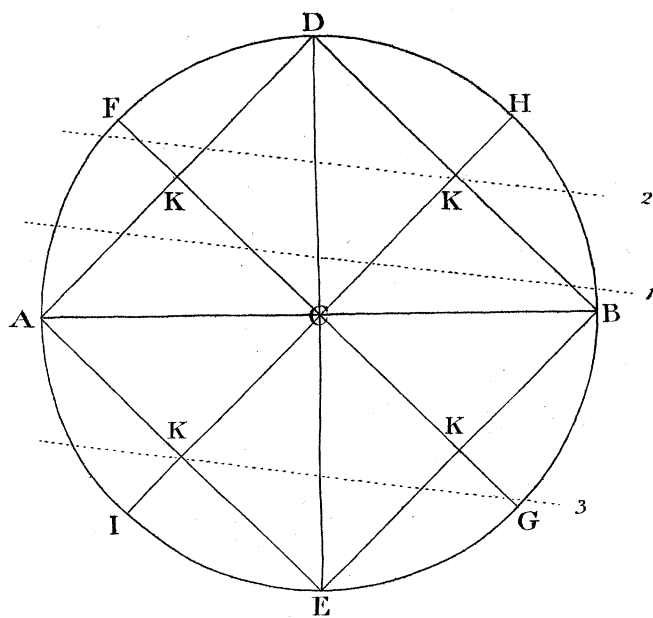


Fig. 2.

